PERFORMANCE OF FLOODWATER RETARDING STRUCTURES NEAR McKINNEY, TEXAS DURING STORM OF SEPTEMBER 20-21, 1964

Prepared by
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
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General

This report describes the performance of floodwater retarding structures near McKinney, Texas, during the storm of September 20-21, 1964. A special storm report covering East Fork Above Lavon Watershed was made. This report indicates that the emergency spillways functioned on seven floodwater retarding structures located west and southwest of McKinney. Two of these structures, 1B and 2A, had slight flow. Two others, structures 3A and 3D, flowed about one foot deep in the emergency spillway without causing structure damage. Structure 3C flowed about 3.2 feet deep in the emergency spillway and no damage to the structure resulted.

Structure 3B flowed about 3.3 feet deep in the emergency spillway. Scour damage occurred on the lower half of the emergency spillway exit channel.

Structure 5A flowed about 4.2 feet deep in the emergency spillway. Structure damages were limited to the lower one-fourth of the emergency spillway exit channel.

The following table shows the drainage area, estimated storm rainfall and runoff, detention storage capacity and maximum principal spillway discharge capacity for each of the above structures.

Structure No.	Drainage Area	Estimated Rainfall	Estimated Runoff	Detention Storage Capacity	Principal Spillway Discharge Capacity
	Sq.Mi.	Inches	Inches	Inches	CSM
1B	2.06	5.80	4.71	4.06	5.9
2A	6.43	5.80	4.71	4.36	10.0
3A	0.79	6.50	5.40	3.24	13.2
3B	2.64	10.30	9.20	4.04	9.9
3C	1.43	10.30	9.20	5.20	8.4
3D	0.99	10.30	9.20	5.26	11.2
5A	1.91	12.50	11.40	5.28	5.2

Rainfall

During the month of September 1964 the Weather Bureau standard gage at McKinney recorded 21.57 inches of rainfall (figure 1). The gage is observed at 7:00 a.m. each day. When the storm came on September 20-21, antecedent rainfall was such that a condition III existed on the watershed. It is estimated that the rainfall-runoff relationship for this storm should be based on Curve No. 91.

The USGS maintains recording rain gages on nearby White Rock Creek Watershed. Rainfall recorded at gage 2-W was approximately the same as that

gaged at McKinney. Local storm reports indicate rainfall at Structure 5A to be approximately the same as at McKinney. Rainfall at Structures 3B and 3C was estimated to be about 82 percent of the McKinney total. Distribution was based on records from gage 2-W. Figure 2 shows this distribution.

Flood Routings

Hydrographs for the September 1964 flood were prepared for Structures 3B, 3C, and 5A using the incremental hydrograph method. These were routed through the respective structures. Also, the Class (a) State and Washington minimum freeboard hydrographs were routed through Structures 3B and 5A. Flood routings were begun in Structures 3C and 5A with the pool level at the principal spillway crest.

Structure 3B has a principal spillway port located at the 200 acre-foot level. Routing of the September flood was begun with detention storage beginning at the elevation of the port. Routing of the freeboard hydrograph was begun with the pool level at the principal spillway crest.

Figures 3A, 3B and 3C show the inflow and outflow hydrographs for the September 1964 flood. Figures 4A and 4B show the inflow and outflow hydrographs for the Class (a) freeboard hydrograph storm at Structures 3B and 5A.

The minimum six-hour precipitation for developing the freeboard hydrograph for a Class (a) structure near McKinney is 9.8 inches (Washington Engineering Memorandum-27). These minimums have been increased in Texas. The minimum State requirement for Class (a) structures near McKinney is 14.3 inches.

Structure Data

Table 1 lists pertinent data concerning floodwater retarding structures Nos. 3B, 3C and 5A. Detention capacity as shown on the table includes sediment storage capacity above the principal spillway outlet. Because the structures had been built less than 8 years, it was considered that most of the original sediment capacity (allocated to the detention pool) was still available for storage of water.

At the time these structures were built, the top of the dam was designed one foot above the freeboard hydrograph maximum water surface elevation. Thus, if these structures were designed using current criteria, the top of dam elevation would be one foot lower than is shown in the table.

The emergency spillways were shaped and had a fair to good cover of bermudagrass when the flood occurred.

All emergency spillways have a 50-foot level crest section and a level spillway entrance section two feet lower than the crest.

The emergency spillway exit channel for Structure 3B was constructed with a slope of 5.6 percent for 300 feet below the control section. The slope on the remaining 438 feet was increased to 8.1 percent. This graded into the creek bottom downstream from the structure. The grade line of the exit channel intercepted some rock ledges at about Station 9+00. Water has seeped from along this ledge keeping the downstream area of the channel wet.

The emergency spillway exit channel for Structure 3C was constructed with 3.47 percent slope for 160 feet. It outleted on top of a creek bank and fell about 10 feet vertically to the grade of the creek. The creek bank is underlain with fractured limestone and is very slowly erosive.

The emergency spillway exit channel for Structure 5A slopes 13.6 percent from the control section downstream. At about 100 feet below the control section, outflow is permitted to spread over a wide pasture area.

Figures 5A, 5B and 5C show the plans and profiles of the emergency spillways.

Flood Analyses

Table 2 compares the September 1964 flood at Structures Nos. 3B, 3C and 5A. It shows the maximum pool head and the maximum velocity reached in the emergency spillway exit channel of each structure. The highest pool head of 4.2 feet occurred at Structure 5A. A maximum of 3.3 and 3.2 feet was reached at Structures 3B and 3C, respectively. Maximum computed velocities in the exit channels were 16.7 ft/sec. at Structure 5A, 12.3 ft/sec. at Structure 3B, and 9.3 ft/sec. at Structure 3C.

The relation of velocity in the emergency spillway exit channel and duration is plotted on figure 6.

The September 1964 flood is compared on Table 2 to the Class (a) freeboard hydrograph storms for Structures 3B and 5A. The flood flows from Structure 3B exceeded the minimum Engineering Memorandum W-27 and approached the minimum State freeboard hydrograph flood. It exceeded both Engineering Memorandum W-27 and State minimums at Structure 5A.

Structure Damages

Structure damages were limited to the emergency spillway exit channels. Figures 5A, 5B and 5C show the approximate area of the damage.

It appears that damage to Structure 3B began in the area where natural seepage along the limestone outcrop kept the soil saturated. The saturated soils moved out and this started an overfall condition which progressed upstream. About 2500 cubic yards of soil was removed from the spillway.

Structure 3C had slight damage to the emergency spillway. The fractured limestone overfall into the creek moved up the spillway exit channel approximately 20 feet. No repairs were needed.

Damage to the emergency spillway of Structure 5A was limited to the removal of about 100 cubic yards of soil.

Conclusions

The September 1964 flood at Structure 5A exceeded the Class (a) freeboard hydrograph flood presently used in the State. It exceeded the minimum required by Engineering Memorandum W-27 at Structures 3B, 3C and 5A.

Damages to the structures were limited to the emergency spillway exit channels. The lower end of the exit channel on Structure 3B was saturated by natural seepage. It is likely that this saturated soil moved out leaving an overfall condition which progressed upstream. Structure 5A had a steeper emergency spillway exit channel with higher velocities and longer duration of flow in the channel than Structure 3B, but damages were less severe.

This study reflects no need to change present design criteria.

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Table 1
STRUCTURE DATA

	UNIT	Structure Number 3B	3C	5A
Drainage Area	Sq. Mi.	2.64	1.43	1.91
Detention Capacity[1/]	Inches	5.11	5.39	5.45
Emergency Spillway Crest Elevation	MSL	667.5	633.8	590.0
Top of Dam Elevation	MSL	672.5	638.3	594.9
Principal Spillway Capacity	CSM	9.9	8.4	5.2
Emergency Spillway Width	Feet	150	100	100
Emergency Spillway Exit Channel				
Slope	Percent	5.6 & 8.1	3.5	13.6
Length	Feet	300 & 438	160	110

1/ Includes capacity between port and principal spillway on Structure 3B and sediment storage capacity provided in the detention pools.

Table 2
FLOOD ANALYSES

	Unit	Structure Number 3B	3C	5A
1964 Flood				
Rainfall				
Total Volume	inches	10.3	10.3	12.5
Duration	hours	8.5	8.5	8.5
Maximum 6-hour	inches	6.8	6.8	8.3
Runoff				
Total Volume	inches	9.2	9.2	11.4
Peak Inflow	cfs	4140	2380	3520
Peak Outflow	cfs	2120	1520	2250
Maximum H_p	feet	3.3	3.2	4.2
Maximum Velocity in Exit Channel	ft/sec.	12.3	9.3	16.7
Class (a) Freeboard Hydrograph Storm - Engineering-Hydrology Memorandum TX-1				
Rainfall Volume[1/]	inches	14.3		14.3
Runoff				
Volume	inches	11.7		11.7
Peak Inflow	cfs	6200		4320
Peak Outflow	cfs	3100		2050
Maximum H_p	feet	4.1		3.9
Maximum Velocity in Exit Channel	ft/sec.	14.2		15.8
Class (a) Freeboard Hydrograph Storm - Engineering Memorandum-27				
Rainfall Volume[1/]	inches	9.8		9.8
Runoff				
Volume	inches	7.3		7.3
Peak Inflow	cfs	3870		2700
Peak Outflow	cfs	1150		580
Maximum H_p	feet	2.3		1.5
Maximum Velocity in Exit Channel	ft/sec.	11.2		8.5

1/ Duration of storm is 6 hours.

Figure 1 .

RAINFALL RECORDED AT McKINNEY, TEXAS

1964

Precipitation Observed at 7:00 a.m.

	July	August	September	October	November	December
1						
2						
3					.03	
4					1.64	.11
5					.85	
6			.18			
7						
8			T			
9						
10			T			.97
11						
12						
13				.09		
14						
15		1.85	T		T	
16		2.12	.23		T	
17			3.21		.39	
18					2.58	T
19		.34			1.82	T
20			.87			
21			12.10			
22		.14	.47			
23			.99			
24						
25		T				
26				.22		
27		.31	2.80	.03		
28			.72			
29						
30	.20					T
31						
Total	.20	4.76	21.57	.34	7.31	1.08

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Floodwater detention and functioning of emergency spillway at Structure 2A, East Fork Above Lavon Watershed, after the storm of September 20-21, 1964.

Emergency spillway flow at Structure 3A, East Fork Above Lavon Watershed, after the storm of September 20-21, 1964.

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Floodwater being detained behind Structure 3B, East Fork Above Lavon Watershed. Emergency spillway flow with damage at lower end after storm of September 20-21, 1964.

Emergency spillway on Structure 3B, East Fork Above Lavon Watershed, after the storm of September 20-21, 1964.

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Emergency spillway on Structure 3B, East Fork Above Lavon Watershed, after the September 20-21, 1964 storm.

Emergency spillway on Structure 5A, East Fork Above Lavon Watershed, after the storm of September 20-21, 1964.

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Floodwater detention and emergency spillway flow at Structure 3C, East Fork Above Lavon Watershed, after the storm of September 20-21, 1964.

Emergency spillway on Structure 3C, East Fork Above Lavon Watershed, after the storm of September 20-21, 1964.

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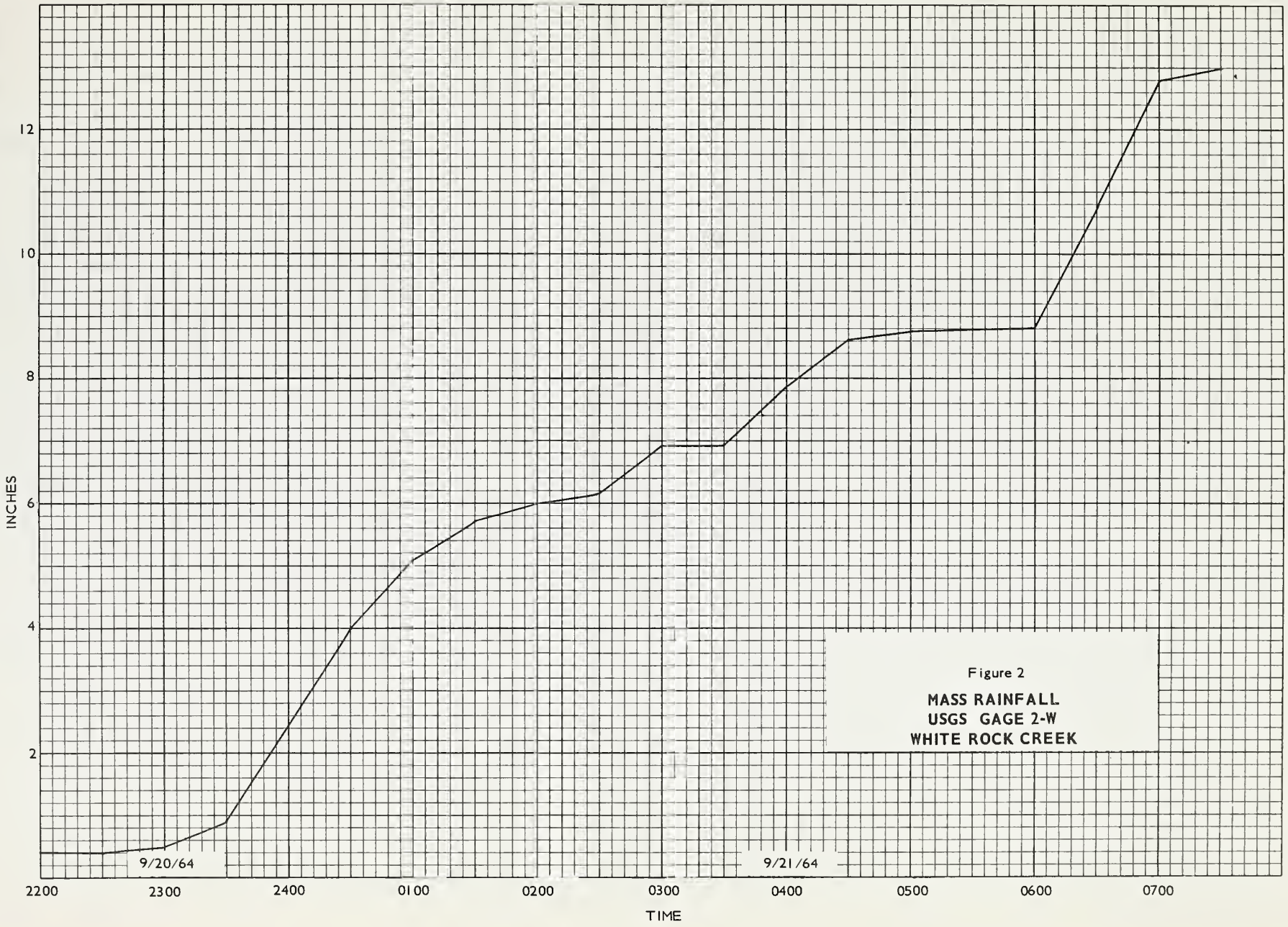


Figure 2

MASS RAINFALL
USGS GAGE 2-W
WHITE ROCK CREEK

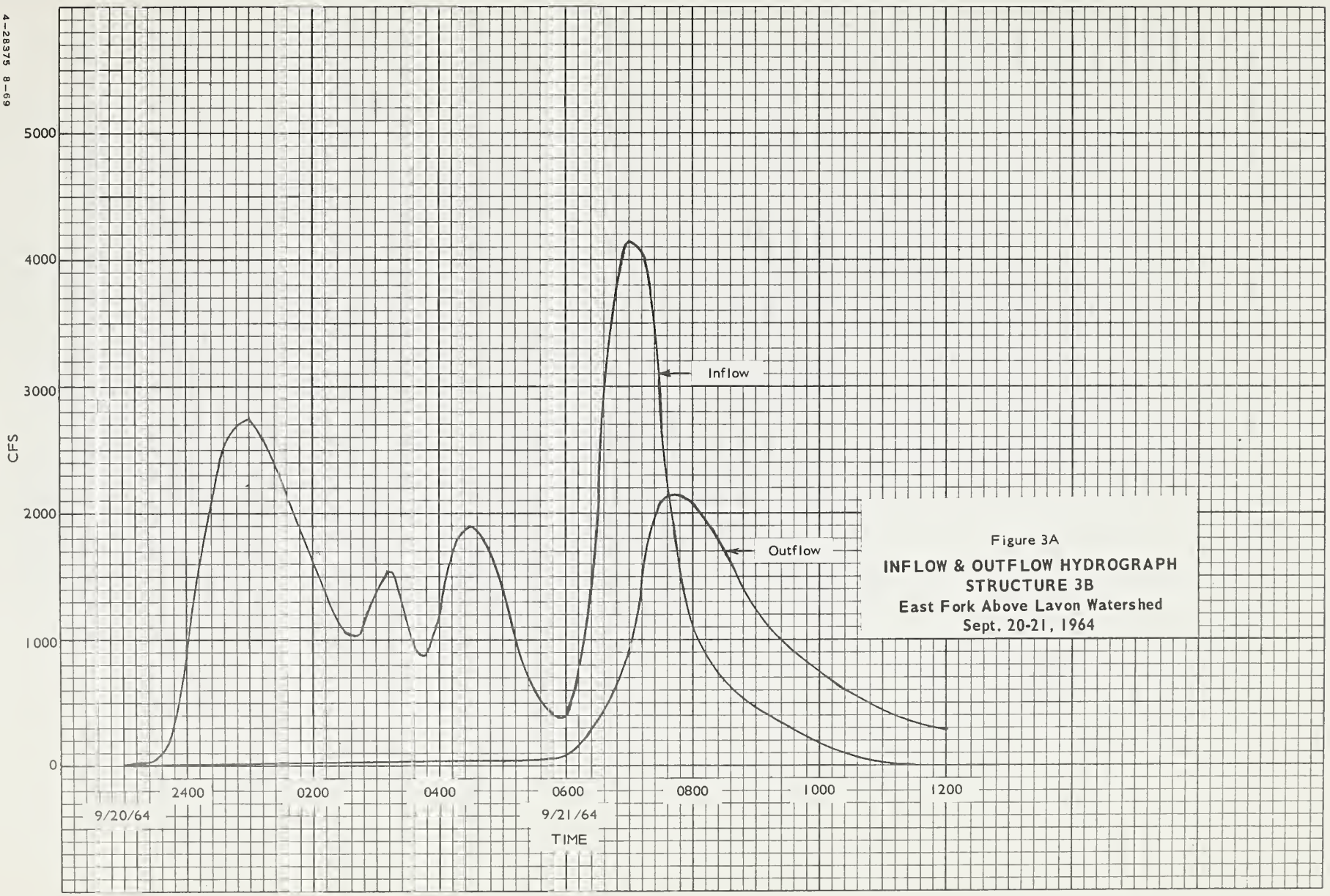


Figure 3A

INFLOW & OUTFLOW HYDROGRAPH
STRUCTURE 3B
East Fork Above Lavon Watershed
Sept. 20-21, 1964

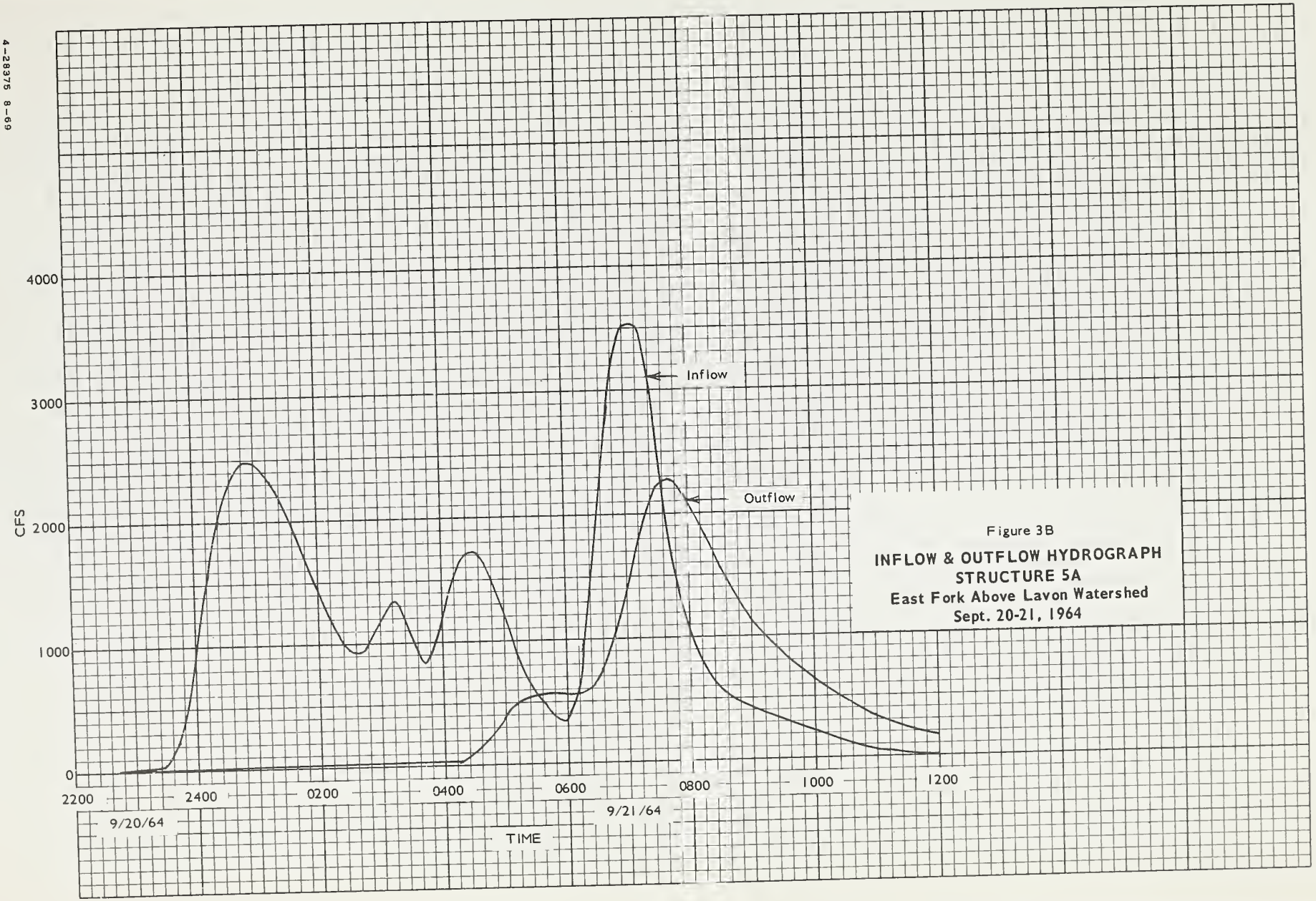


Figure 3B

INFLOW & OUTFLOW HYDROGRAPH
STRUCTURE 5A
East Fork Above Lavon Watershed
Sept. 20-21, 1964

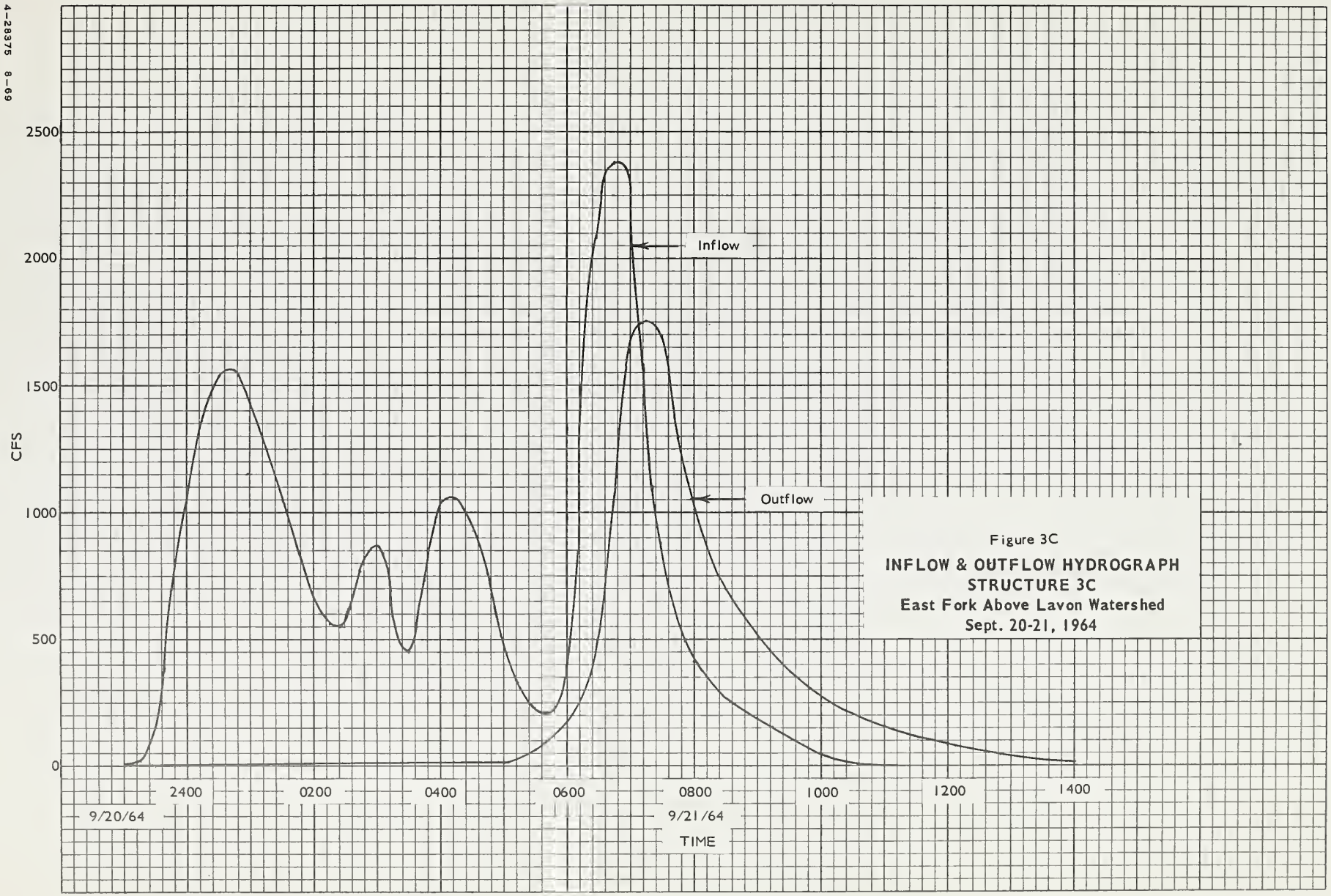


Figure 3C

INFLOW & OUTFLOW HYDROGRAPH
STRUCTURE 3C
East Fork Above Lavon Watershed
Sept. 20-21, 1964

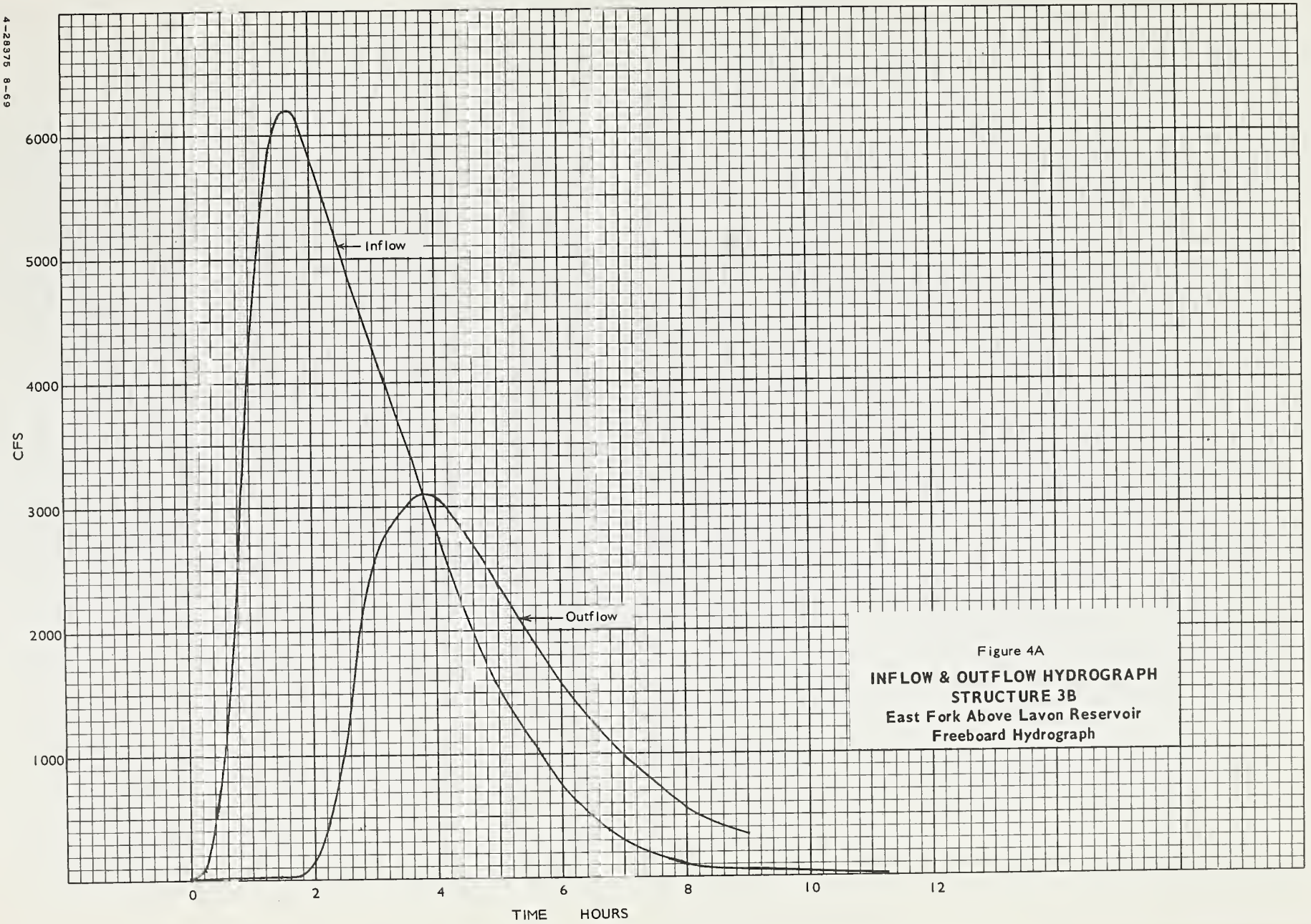


Figure 4A

INFLOW & OUTFLOW HYDROGRAPH
STRUCTURE 3B
East Fork Above Lavon Reservoir
Freeboard Hydrograph

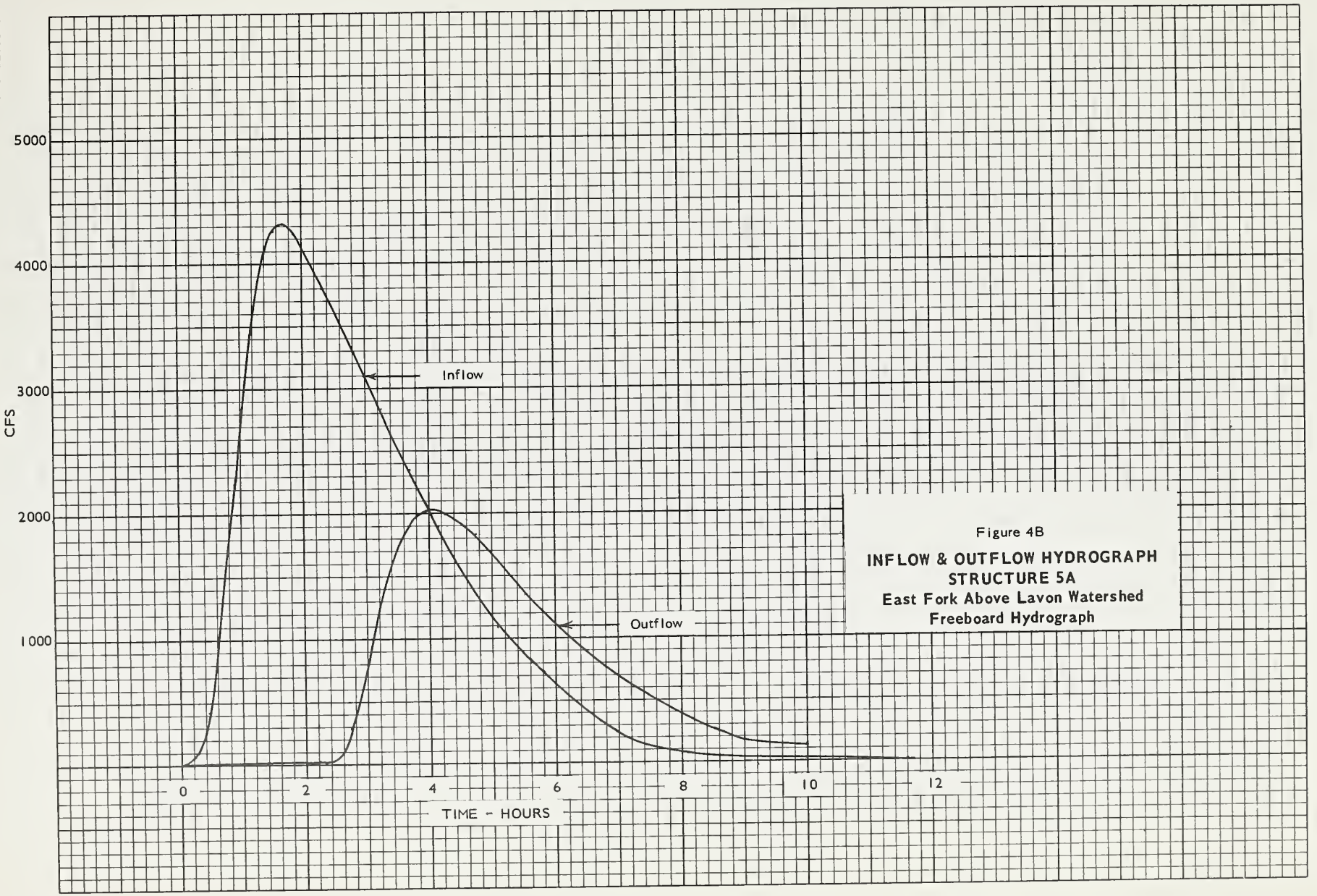
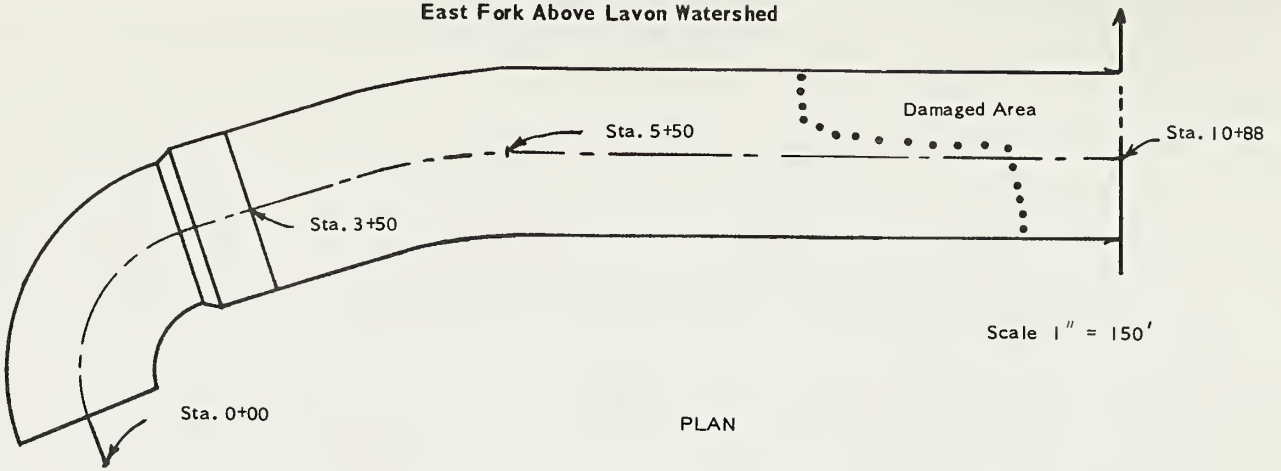


Figure 4B

INFLOW & OUTFLOW HYDROGRAPH
STRUCTURE 5A
East Fork Above Lavon Watershed
Freeboard Hydrograph

Figure 5A

STRUCTURE 3B
East Fork Above Lavon Watershed



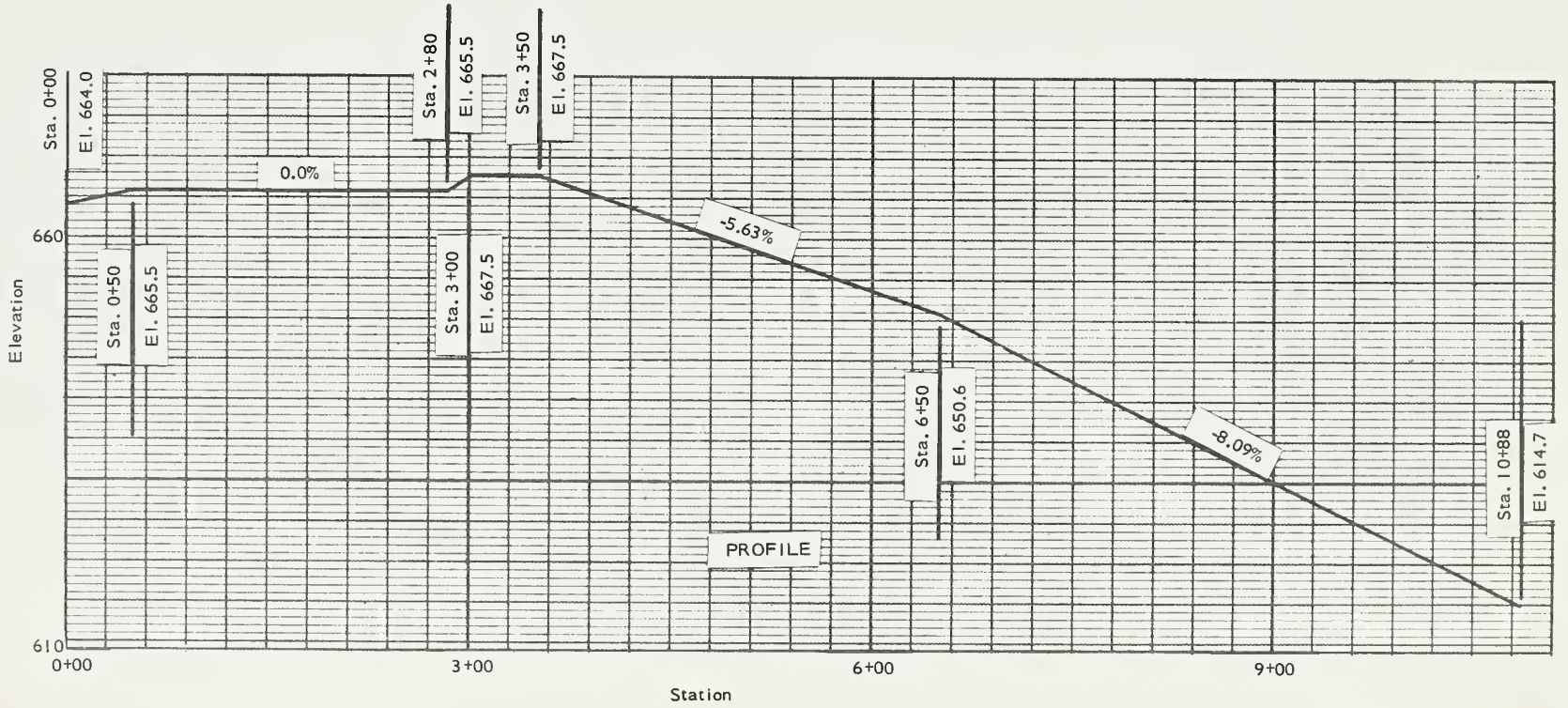
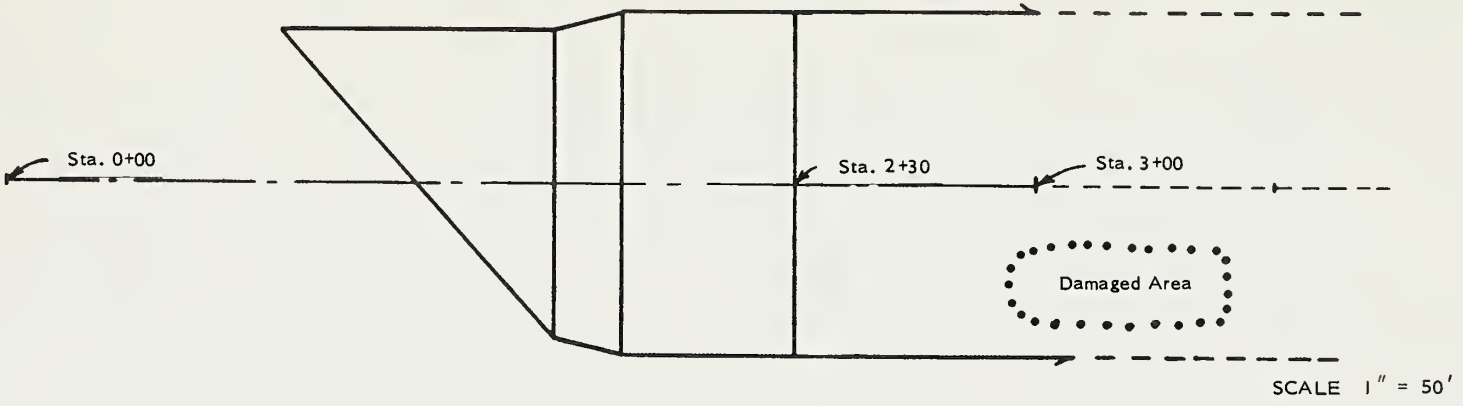


Figure 5B

STRUCTURE 5A
East Fork Above Lavon Watershed



SCALE 1" = 50'

PLAN

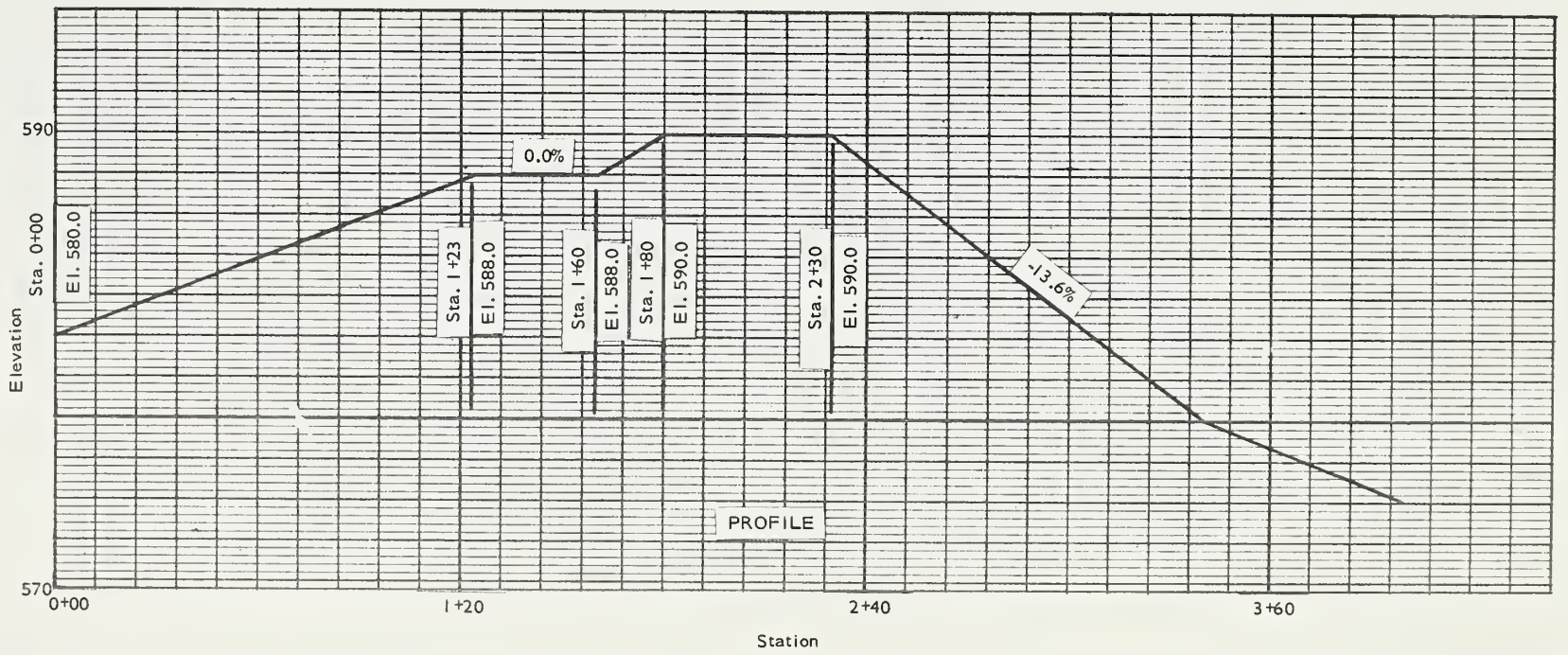
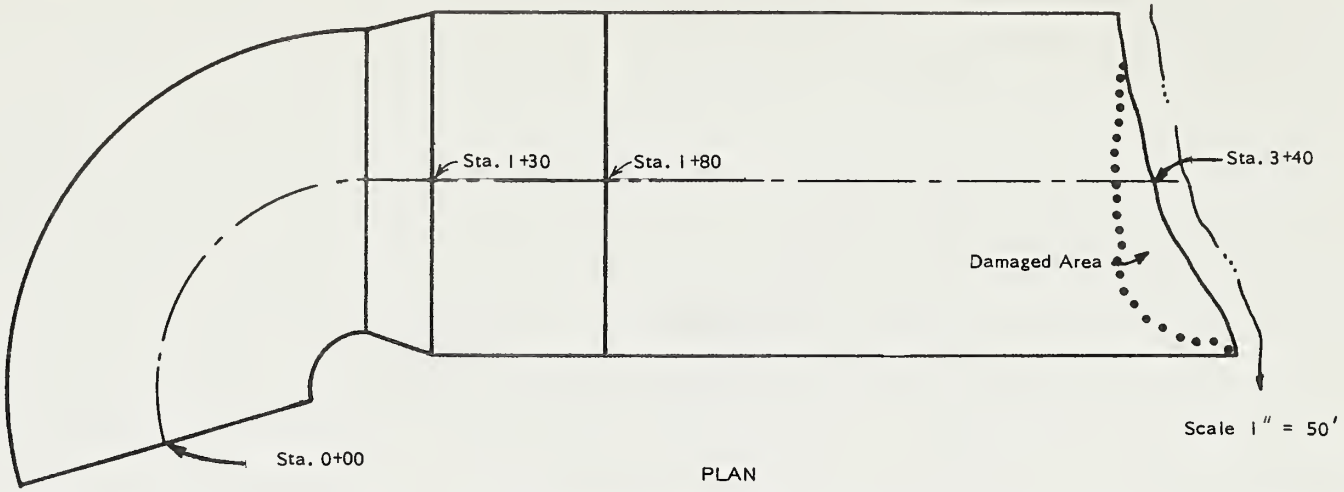
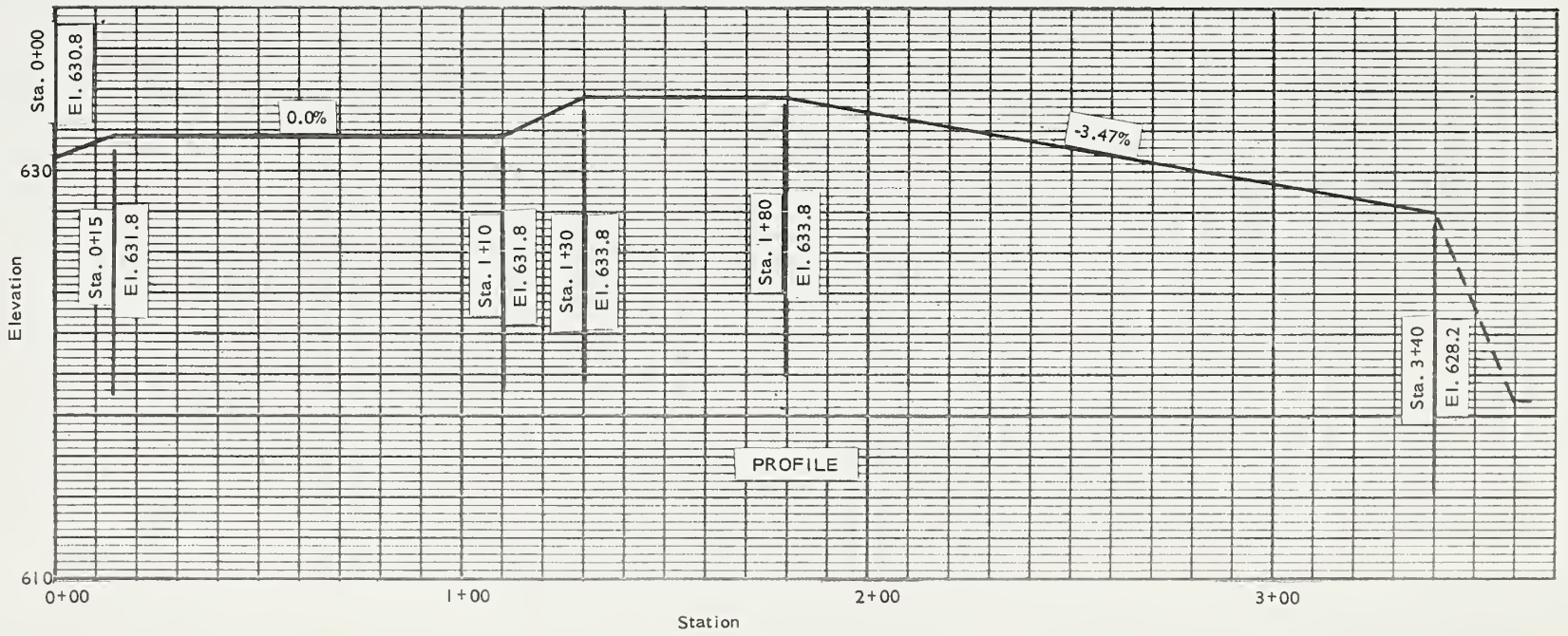


Figure 5C

STRUCTURE 3C
East Fork Above Lavon Watershed



PLAN



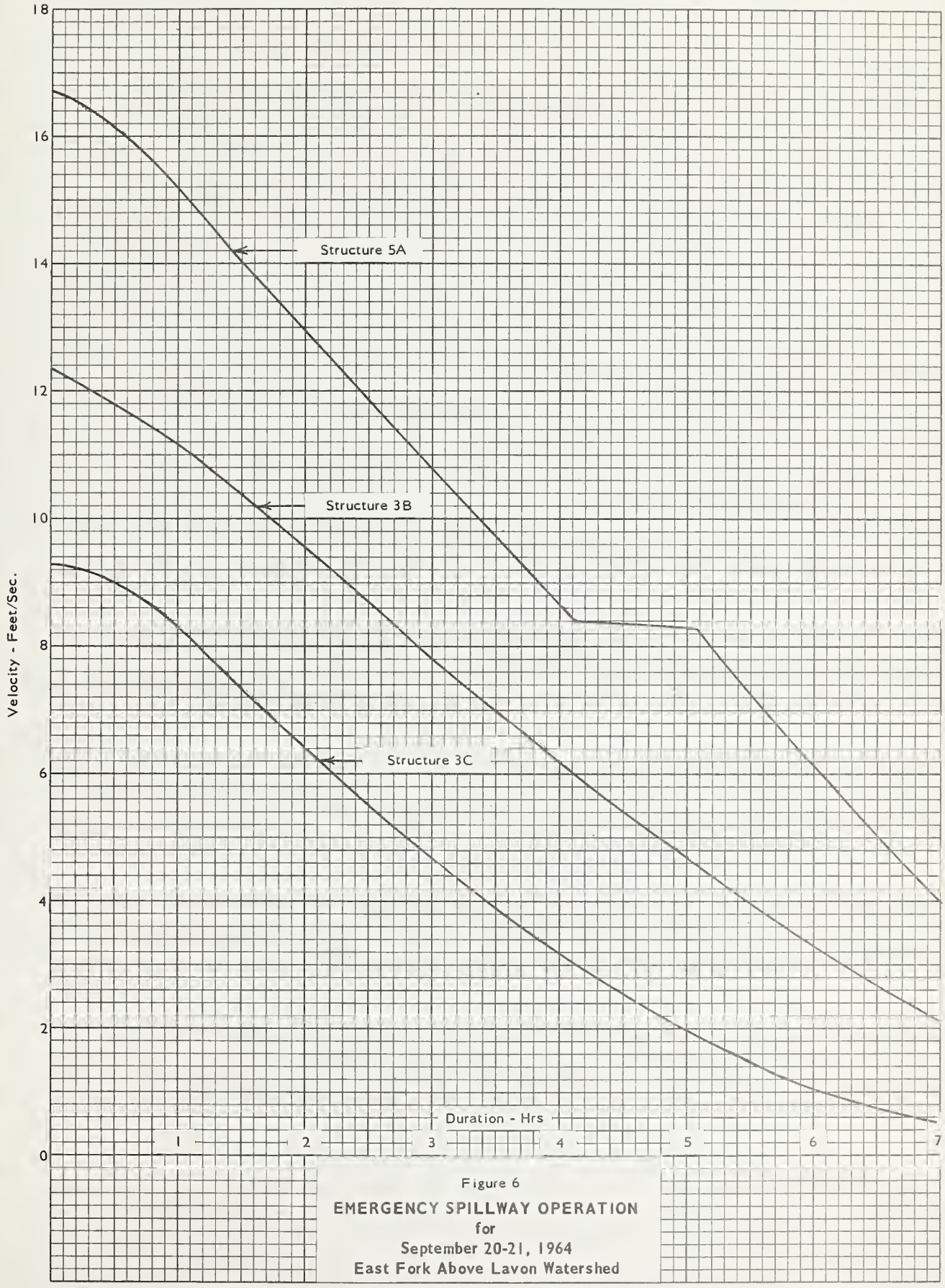


Figure 6

EMERGENCY SPILLWAY OPERATION
for
September 20-21, 1964
East Fork Above Lavon Watershed

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